Impacts of Electrofishing Injury on Idaho Stream Salmonids at the Population Scale

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ABSTRACT—This study assesses the mortality impacts of electrofishing at the population scale based on levels of sampling by Idaho Department Fish and Game (IDFG) and non-IDFG projects during the 1995 and 1996 field seasons. We estimated electrofishing induced population mortality by considering the proportion of stream reach shocked during sampling, the probability of fish exposure to an electric field based on sampling method used, and a hypothesized worst-case (25%) mortality rate for all electroshocked fish. For IDFG mark-recapture estimates the mean mortality from shocking was 1.05% with a range of 0.13-4.02%. For Idaho Department of Fish and Game (IDFG) removal sampling, we estimate a mean population mortality of 0.38% with a range of 0.02-2.91%. For non IDFG sampling mean population mortality averaged 1.11% with a range of 0.05-7.71%. Fifty-one percent of all mortality estimates were less than 0.50%. These low estimates are likely worst-case electrofishing effects because the high assumed mortality value used is not supported by any literature values. We conclude the impacts due to sampling using electrofishing methods does not constitute a meaningful impact to Idaho stream trout at the population level, especially when compared to annual natural mortality levels for most stream salmonids which typically equal 30-60%.

INTRODUCTION

Electrofishing is a widely used and highly effective sampling tool in the management of stream salmonids and other species (Schill and Beland 1995; Reynolds 1996). The use of electrofishing as a sampling tool began in the 1940's and became commonplace in the 1950's and 1960's. Despite the completion of several early injury studies, the technique was considered relatively benign for many years (Reynolds 1996). Recent concern regarding injury of fish collected with electrofishing methods was first raised by Sharber and Carothers (1988), who reported high injury rates for a sample of rainbow trout from the Colorado river. Since this initial effort to quantify injuries, additional studies have documented injury levels of up to 70% for trout sampled using traditional electrofishing methods (Sharber et al. 1994: Fredenberg 1992; Holmes et al. 1990; McMichael 1993; Thompson et at. 1997; Habera et al. 1996). Although short term injury rates from samples of electrofished salmonids often appear to be high, short-term mortality is often low (McMichael 1993; Hudy 1985; Pratt 1955; McCrimmon and Bidgood 1965).

Despite the recent profusion of electrofishing injury studies, few authors have attempted to evaluate long-term survival of injured fish, presumably due to logistical difficulties associated with such efforts. Dalbey et al. (1996) collected wild rainbow trout Oncorhynchus mykiss from a stream via electrofishing, rated spinal injuries using x-rays, and released them in a small pond to examine subsequent survival. The authors found no significant difference in survival of injured and uninjured rainbow trout collected with three electrical wave forms 12 months post treatment. Holmes et al. (1990) found no significant difference in angler catch of trout collected by electrofishing and hook and line methods 1 and 2 years previously. Achord (National Marine Fisheries Service, unpublished data) collected wild juvenile chinook Oncorhynchus tshawytscha from Salmon River tributaries via DC electrofishing and seining and saw no differences in outmigration survival to Lower Granite Dam a year later based on PIT tag recoveries. To date, no published study we are aware of has demonstrated a reduction in long-term survival rate from electrofished salmonids compared to a control sample.

Although often called for (Hollender and Carline 1994; Habera et al. 1996; Hudy 1995), few studies have attempted to evaluate the importance of electrofishing injuries at the population scale. Schill and Beland (1995) presented a simple hypothetical example that suggests typical stream electrofishing sampling would be unlikely to negatively affect a population; however no field data were used. McMichael et al. (1998) elaborated on this approach and, using X-rays and necropsies, quantified electrofishing injury rates for samples of chinook salmon and rainbow trout at the sample, reach and population scales. Based on electrofishing injury rates ranging from 0.1 to 2.1% at the population scale, the authors concluded that impacts at the population scale were unlikely for either species. Habera et al. (1999) also recently noted that population scale impacts from AC electrofishing in Eastern brown trout Salmo trutta streams would not be likely based on their sampling intensity.

Despite the consistent finding of the few studies addressing injuries at the population-scale in salmonids, a more broad-based assessment than those of McMichael et al. (1998) and Habera et al. (1999) would provide additional perspective on risks resulting from electrofishing collection methods. The objectives of this study is to estimate salmonid mortality at the population scale due to electrofishing injury based on actual sampling intensities from a wide variety of Idaho streams.

METHODS

We estimated the probability of electrofishing mortality at the population scale for each sampling effort using the proportion of the stream reach shocked, probability of trout electrical exposure for a given electrofishing application, and an assumed worst case estimate of mortality for fish collected.

One major source of data for this effort was past stream sampling data for salmonids collected by Idaho Department of Fish and Game (IDFG) statewide during 1995 and 1996. IDFG management and research biologists provided a comprehensive list of all streams sampled with electrofishing equipment during both study years. A second source of data for the same two years was derived from collection permit reports required by IDFG for other state and federal agencies, universities, and private consultants to sample Idaho streams. Data summarized from each individual sampling event in both years included a legal description (township, range, section, ¼ section), electrofishing technique used (number of passes if a removal estimate) and the number and length (m) of individual electrofishing sites for each stream.

The proportion of stream reach shocked (P) was calculated by dividing the total length of the sample site (or multiple sites) by the length of the corresponding stream reach. A stream reach, containing a “population” in this study was defined as that portion of a stream reach upstream and downstream of sampling sites that was of the same stream order. This approach was modified only if known migration barriers existed; in those cases population boundaries were adjusted accordingly (Figure 1). A planimeter and 1:100,000 scale BLM land status maps were used to assess stream order and to obtain the length of stream reaches. Actual electrofishing site lengths were included in the sampling data. We assumed electrofishing sample sites were representative of the fish populations at the stream reach scale (McMichael et al.1998). Therefore, the proportion of the habitat sampled was used as a surrogate for the % of trout populations shocked in a given stream reach.

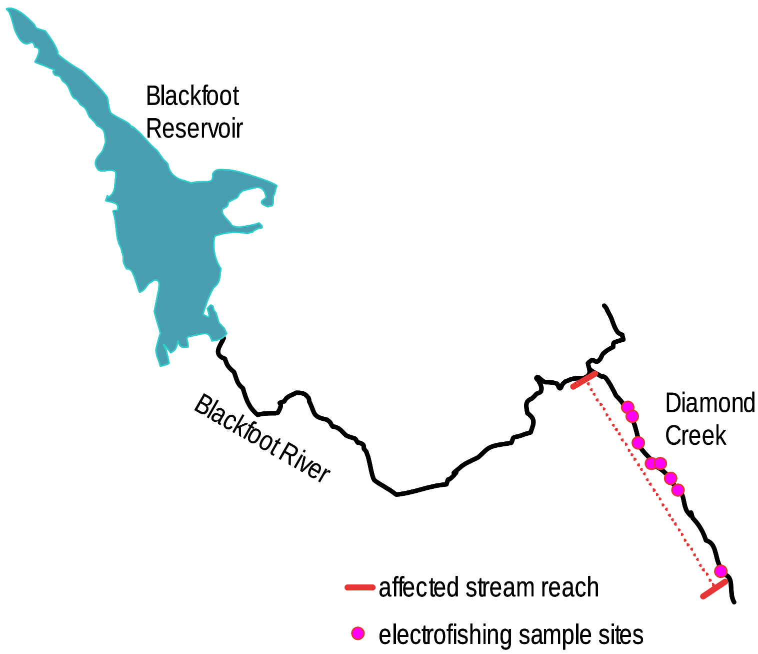

Figure 1. Example of stream reach used for extrapolation from sample to population scale. Expansion of sections was restricted to equal stream order from which samples where collected as determined by 1:100,000 scale maps.

We used 67%, 89%, 96% as the probability of capture or electrical exposure (E) for 1 pass, 2 pass and 3 pass removal sampling. These values represent general capture efficiencies for Idaho streams (Meyers 1999) and are virtually the same as that reported by McMichael et al. (1998). For mark-recapture estimates we used the proportion of fish recaptured as the probability of exposure. This mark-recapture probability was doubled to account for electrical exposure during both the mark and recapture runs (McMichael et al. 1998). Although declines in long-term survival of electrofished salmonids has not been documented relative to control samples, we chose 25% as an estimate of mortality due to electrofishing injury to represent a worst case long-term mortality rate for this study.

The following equation was used to calculate the probability of mortality at the population scale for each sample site or combined sites on a stream reach:

$$M = PE\ (0.25)$$

where M = the estimated mortality resulting for a stream reach;

P = the proportion of the stream reach length shocked during sampling;

E = the probability of trout electrical exposure per site based on the sampling method applied.

Results

IDFG Sampling

IDFG sampled 162 stream reaches during 1995 and 1996 using electrofishing methods, the majority of which were done with two or three pass techniques for population estimation (Table 1). Using the two criteria established above to identify population boundaries, sampling at the reported intensities typically results in a small proportion of available habitat being electrofished.

Estimated mean mortality resulting from electrofishing injury at the reach or population level equaled 0.46% for all samples combined. The range of estimated mortality was 0.02-4.02% for all sections (Table 1).

Table 1. Summary of electrofishing mortality estimates at the population scale for 162 stream reaches sampled by Idaho Department of Fish and Game (IDFG) and 305 stream reaches sampled by non-IDFG agencies during 1995 and 1996.

Sample Effort	No. of sample reaches[1]	Estimated Mortality[2] (%) Mean	Std	Range
IDFG				
Mark-recapture	25	1.05	0.88	0.13-4.02
Removal				
One pass	10	0.45	0.52	0.02-1.73
Two pass	68	0.39	0.45	0.05-2.91
Three pass	59	0.30	0.34	0.04-1.65
Total	**162**	**0.46**	**0.57**	**0.02-4.02**
Non-IDFG Agencies				
One pass	204	0.95	1.01	0.05-7.71
Two pass	21	0.48	0.24	0.13-1.13
Three pass	80	1.69	1.02	0.15-4.00
Total	**305**	**1.11**	**1.04**	**0.05-7.71**

[1] *Stream defined as the length of stream.*
[2] *Mortality due to electrofishing at the sample level reported as a percentage of the population with a stream reach.*

Mark-recapture sampling had higher associated mortality (mean = 1.05%) compared to one, two, and three pass removal methods (mean = 0.30-0.45%), although estimated mortality associated with all collection methods was low (Table 1). Mark-recapture estimates typically required a longer sample section to produce an estimate, resulting in a higher proportion of the stream reach being sampled. The highest mortality estimate was 4.02% in one mark-recapture estimate. Eighty-two percent of the IDFG samples had estimates of 0.50% or lower (Figure 2). Eighty-eight percent of stream reaches sampled had estimated population mortality impacts <1.0% and only one of all worst-case IDFG estimates exceeded 3%.

NonIDFG Sampling

Non IDFG electrofishing accounted for sampling in 305 Idaho stream reaches during 1995 and 1996. Most non IDFG sampling consisted of one pass electrofishing efforts for species composition (Table 1). Estimated mean mortality at the population scale equaled 1.11% for all sites with a range of 0.05-7.71% (Table 1). Several projects completed intensive sampling associated with research and fish tagging projects which resulted in the higher mortality estimates. Thirty-seven percent of the stream reaches had estimated mortality impacts of 0.50% or less (Figure 3). Fifty-three percent of the population mortality estimates were < 1.0% with the maximum mortality impact of 7.71% in a consultant presence/absence sample which extended over the entire stream reach.

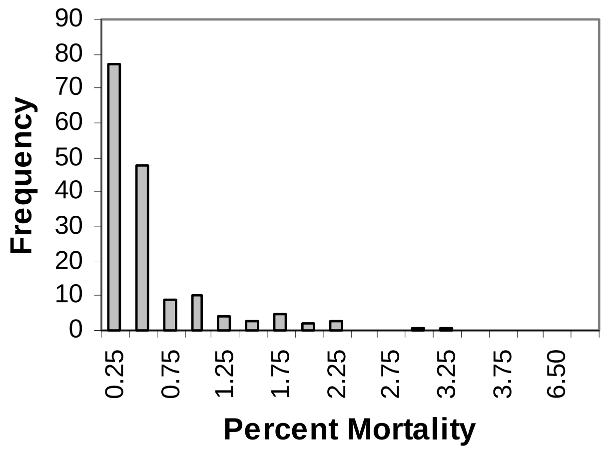

Figure 2. Distribution of estimated mortality at the population scale by Idaho Department of Fish and Game in 162 stream reaches during 1995 and 1996.

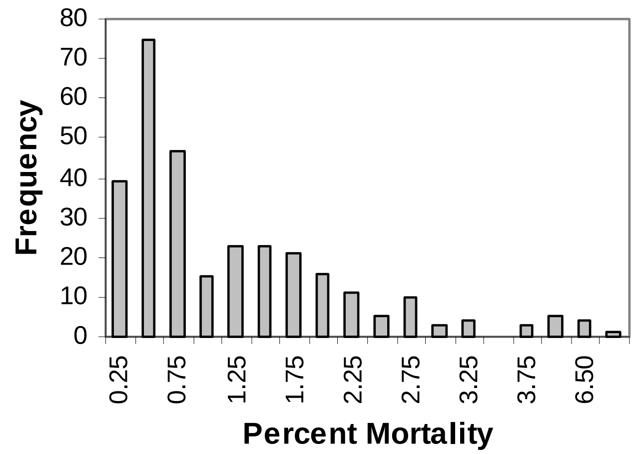

Figure 3. Distribution of estimated mortality at the population scale by non-IDGF agencies in 305 stream reaches during 1995 and 1996.

Discussion

Based on high injury levels at the sample scale, restrictions on the use of electrofishing collection methods and wave forms have been initiated and called for (Nielsen 1998). Alaska banned electrofishing methods on trophy trout management waters (Holmes et al. 1990) based primarily on fishing guide observations of injured fish (J. Reynolds, University of Alaska, pers communication). Montana has restricted the use of pulsed direct current over 30 Hz (Fredenberg 1992). Snyder (1995) suggested electrofishing methods should not be used when working with sensitive species. Bonar et al. (1997) suggested that electrofishing not be used to collect bull trout in Washington. These suggested or implemented policy shifts were based on injury rates observed in samples of salmonids collected with electrofishing techniques.

However, Habera et al. (1995) cautioned against “dismissing the legitimacy of any sampling gear or technique based on undetermined effects observed in a limited context”. A growing number of relatively recent studies have begun to assess electrofishing impacts at the population scale. Schill and Beland (1995) suggested population scale injury and mortality rates in a hypothetical stream sampling situation would likely equal about 2.4% and 1.2%, respectively. McMichael et al. (1998) provided the first actual field evaluation of electrofishing effect on salmonids at the population scale. These authors estimated that the population injury rate (not mortality) for their standard monitoring program ranged between 0.1 to 2.1% in chinook salmon and rainbow/steelhead trout in the Yakima basin. If only a fraction of injured fish in their study would eventually die or experience reduced growth, as suggested by the literature (e.g., Dalbey et al. 1996),the resultant effect on the population would be even lower. Habera et al. (1999) concluded that electrofishing for brown trout could have little population effect on brown trout in a Tennessee stream based on observed injury rates and the proportion of habitat sampled. Carline (this symposium) demonstrated that multiple-year electrofishing of brown trout did not result in detectable population differences compared to a nearby control population. Our results in this study are similar and suggest electrofishing as presently conducted in Idaho would be highly unlikely to impact a salmonid population.

In our study we applied 25% mortality as a worst case scenario to the estimates of injured fish in the electrofishing sample collection. Few long term estimates of mortality related to electrofishing injury are available. Dalbey et al. (1996) found 54-60% survival 335 d post shocking. However, they found no difference in survival between injured and uninjured fish nor between differing electrical waveforms used during collection. Further, they could not separate natural from electrofishing induced mortality. Short term (up to 14 days) mortality reported in electrofishing injury in recent studies ranges from 0-14% (Hollender and Carline 1994; McMichael 1993; Holmes et al. 1990). By applying a worst case estimate for mortality (25%), we believe our estimates of electrofishing related mortality represent the high end of possible impacts to the population.

Several limitations in our study methods should be considered. We used standardized values for trout electrical exposure during multiple pass electrofishing sampling in 1995 and 1996. The values represent a general average for capture efficiencies derived from 2 and 3 pass removal estimates in Idaho (Meyers et al 1999). We did not attempt to adjust capture efficiencies or mortality rates for size or species of fish collected. A final limitation of this study is our assumption (as in McMichael et al. 1998) that sample sections are representative of abundance and densities of the larger population within adjacent reaches of the same stream order. Due to worst case mortality applied, we do not believe these generalizations significantly effect our conclusions.

Although electrofishing impacts at the population scale effects appear unlikely (Schill and Beland 1995; McMichael et al. 1998; Habera et al. 1999; the present study results), injuries to individual fish are important. Public perception regarding injuries of individual fish may override the best studies that document limited impacts on the sample and population scales, thereby resulting in major restrictions in the use of electrofishing methods (Schill and Beland 1995). We strongly support efforts to reduce injury of salmonids due to electrofishing collection and suggest biologists use smooth DC or low frequency pulsed DC when capture efficiencies can still be maintained (Reynolds and Holliman, this symposium).

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